ALL
SORTS
OF
Wheel-Carriage,
IMPROVED.

Wherein it is plainly made appear, that a much less than the usual Draught of Horses, &c. will be requir'd, in Waggons, Carts, Coaches, and all other Wheel Vehicles, as likewise all Water-Mills, Wind-Mills and Horse-Mills.

This Method being found good in Practice, by the trial of a Coach and Cart already made, shews of what great Advantage it may be to all Farmers, Carriers, Masons, Miners, &c. and to the Publick in general, by saving them one half of the Expences they are now at in the Draught of these Vehicles, according to the common Method.

The whole illustrated with Copper Plates.

And an Explanation of the Structure of a Coach and Cart, according to this Method,

By *JACOB ROWE*, Esq;

LONDON:

Printed for ALEXANDER LYON under *Tom's* Coffee-house in *Russel-Street Covent Garden.* MDCCXXXIV.

ADVERTISEMENT.

THE Author has obtained a Patent from his Majesty, invefting him with the fole Right and Property of making and vending all the ufeful Machines defcribed in this Treatife.

THE
PREFACE.

*E*VERY *body is sensible that the obstructions occasioned by Friction, or the mutual rubbing of the Parts in the mechanic Powers, is so very considerable, that we have been seeking out for a remedy these many years past ; such for instance as has been practised at Sea in weighing of Anchors, Rollers variously applied, and a great many other such contrivances in different cases. From all which it appears to me that most People have imagined the Friction to be owing more to the quantity of Surface in which the parts of a Machine touch, than to the Pressure or Weight ; whereas I have proved the contrary by many Experiments. And I may further justly observe, that if the nature of Friction had been so far considered as to discover the general method of diminishing it, they could not but have applied it to Wheel Carriages, Blocks at Sea, and most Mechanic Engines, in order to have saved great charges and hard labour.*

In drawing a Wheel Carriage on plain ground, the Force to be overcome by the Draught is the Friction of the Pevets on the Nave, which by my contrivance is so far diminished as to give a

Wheel.

The PREFACE.

Wheel Carriage the same advantage over the Common Ones as they have over a Sledge or a Carriage which drags along, and has no Wheels at all; this is the case let the Load be never so great, so as the Road be plain and level. And even up a Hill of a common steepness a Horse can draw as much as two in the old way; nay, as much as a Team up a very steep Hill by an additional improvement of mine.

It is now about seven years since I wrote this Treatise, just as it now appears, which I communicated to several Friends, particularly Robert Bruce *of* Sunbrough *Esq; and Mr.* William Evans *Shipwright in* Deptford *in the year* 1727, *from whom I had the satisfaction to find that the Principles on which I proceed were approved of as solid and true. And about two years ago I had Models made, which shewed that the Practice agreed nicely with the Theory. I then performed the Experiments before several Persons of Quality, and had their countenance and approbation so far, that they advised me to take out a Patent for my Inventions, part of which I have here described according to the best of my judgment.*

INTRODUCTION.

OF THE

DEFINITION of FRICTION.

FRICTION is the Refiftances made between the Surfaces of any Bodies rubbing on each other by any fort of Motion; and is of two kinds, either natural or accidental: Accidental is what is occafioned by the roughnefs or the unevennefs of the Surfaces of the rubbing Bodies; and is therefore more or lefs as the faid Surfaces are more or lefs uneven: fo that very fmooth or well polifhed Bodies may be faid to have little or no Friction, but what may be then called natural Friction; which latter will always be greater or lefs, according as the rubbing Bodies bear more or lefs Weight or Preffure on each other's Surfaces; which Weight or Preffure will occafion confiderable Clogs or Obftructions in the operation of all mechanic Powers where Wheels or Pullies are concerned; which Obftructions or Friction

B   doth

doth wholly lie on the Pevets of the said Wheels or Pullies ; and to know the exact Proportion of the said Friction against the whole Power to be raised, three things must be duly considered ; *viz.* First, the whole Weight that the Wheel or Pulley doth bear on the Pevets of its Axis : Secondly, the Semidiameter of the Axis in the Pevets; and Thirdly, the Distance of the point of Action from the Center of the Axis: and then the Proportion will be ; as the acting Distance is to the Semidiameter of the Axis in the Pevets, so is the whole Weight resting on the Pevets to the resistance made by the Friction thereof; as is demonstrated in the following Chapter.

CHAP.

CHAP. I.

In raising any Power by Wheel, Pulley, Winch or Windlass to determine the resistance made by the Friction of their Pevets.

IN Plate the Ist let Figure Ist represent a large loaded Wheel whose Weight or Pressure on its Pevets (at *b* and *c*) I suppose to be 2000 or a Tun; whereby the said Wheel is in a manner held fast at the bearing Lines of the said Pevets, as by a Power equal to 2000 pound weight, which Power lying in the Surface of the Axis, cannot be balanced by any other Power acting in the same Surface (endeavouring to turn the Axis) under 2000 pound before the bearing Lines of the Pevets will begin to yield or to turn out of their station to give place to new bearing Lines, at which time the Axis will bear on one side of the Groove or Passage the Wheel turns in (on one of its Fulcrum Lines *z* or *q* which Fulcrums are always on the sides of the Pevets at the distance of a Quadrant from the bearing Lines) at the rate of full 2000 pound; so, that if the same Power as beforementioned is at any greater

B 2　　　　distance

diſtance from the Axis than at the Surface
thereof, the ſaid Power will then be able to
over-balance the Friction by as much as the
remote diſtance is proportionably greater
than the diſtance from the Surface of the
Axis to the Center thereof; which is the
property of the Leaver, and may be better
underſtood from conſidering the different
effect of the ſame Power acted in the Cir-
cumference of concentric Circles as follows.

Viz. Suppoſe *d*, which is the Center of the
great Wheel's Axis to be likewiſe the Center
of three concentric Circles, the Radii of the
ſmalleſt equal to *d e*, equal to the Semidiameter
of the Wheel's Axis in the Pevets, the Radii
of the ſecond Circle *d f*, equal to five *d e*,
and the Radii of the largeſt *d g*, equal to
ten *d e*, of the ſaid Semidiameters: and
then *b h*, being the bearing Line of the
Pevets, at *h* in the little Wheel's Periphery
(or at the Surface of the heavy Wheel's Axis)
ſuppoſe the ſame to be held faſt by a Power
to prevent the turning of the Axis equal to
the Friction (equal to 2000 pound) then, it is
certain that in the little Wheel's Periphery no
Balance or Power leſs than a Tun is able to ba-
lance

lance the said Friction; but at the Distance of f in the Periphery of the second Circle (according to the property of the Leaver imagining d to be the Fulcrum) a Force acted equal to but 400 will balance 2000 at h; and a Power equal to 200 acted at g, will balance the said 2000 at h: Or the same may be conceived from the nature of the Still-yard, imagining d to be the center Pin, and d, g to be the Beam having 2000 weight hung at h; and then it is plain, that the said 2000 weight will be balanced at e with 2000, at f with 400, at g with 200; and in each case it is very visible, that,

As the acting distance from the Center of the Axis is to the Semidiameter of the Pevets, so is the whole weight resting thereon to the resistance made by the Friction. which was to be proved.

C H A P.

C H A P. II.

Shewing the manner of cancelling or reducing the Friction of any Wheel, Pulley, Windlass, &c. to the lowest degree of Perception.

AS the Friction is caused by the Resistance of a dead and fixed Surface on which the Pevets of any Wheel, &c. do rest, so can there be no other way of cancelling the said impediment but by causing the said Pevets or the end of the Axis to turn on the Vertex or Top of other Wheels; which Wheels serving only for this purpose may be properly called pevet or friction Wheels: And, by encreasing the number of these friction Wheels (one under the other) so as their Pevets may also rest and turn round on the Vertex or Top of each other (except the Pevets of the last which must turn on a dead Surface as common) the Friction of any great and heavy Wheel may be reduced to the lowest degree of Perception.

E x-

EXAMPLE I.

SUPPOSE in Figure the IId of Plate the Ift the Pevets of a great Wheel to reft each of them on the top of the two other Wheels at *a*, and at *b*, by falling into the Pillars or Stands on which the great Wheel is fupported, which Wheel I fuppofe to weigh or prefs on its Pevets at the rate of a Tun or 2000 pound: and fuppofing the fame to be turned by the Handle *c*, at the Diftance of ten Semidiameters of the Axis from its Center; then, according to what is proved in the firft Chapter, it will require a Force equal to 200 pound to turn the Wheel; but here the property is quite altered, for the whole weight of the great Wheel is now fupported by the Pevets of the two Friction Wheels, each bearing 1000 pound weight on its Pevets: and fuppofing the Semidiameter of each Friction Wheel to contain 100 Semidiameters of their Axis in the Pevets; then, by what is demonftrated in the firft Chapter, it's very plain, that the force of ten pound in the Periphery of each Friction Wheel will juft balance the Friction of their

Pevets,

Pevets, requiring in the whole a Force of twenty pound; and consequently a Force of but two pound on the handle at *e*, being the distance of ten Semidiameters from the Center of the Axis, will generate a Power in the Circumference or at the Vertex of each Friction Wheel equal to ten pound; so that the great 'Wheel which at first, without taking off the Friction, required a Force of 200 pound acted on the handle to turn the same, will now be turned (by means of the two Friction Wheels) with a Force of but little more than two pound.

REFLECTION.

BY the foregoing Example it plainly appears that the Friction will be diminished more or less according to the Dimension of the Pevet or Friction Wheels, and the Diminution would always be exactly in the same Proportion as the Diameter of the Friction Wheel's Axis in the Pevets is less than the Diameter of the Friction Wheel; was there not some allowance to be made for accidental Friction both in the bearing Line and in

5   the

the Fulcrum Line; which latter may be made imperceptible by the Axis of the great Wheel turning againſt two little Wheels (in the room of a dead Surface) placed between the Friction Wheel and the Stand, and the Shoulders of the Axis may have their Friction taken off by their bearing againſt the inſide of the ſaid Fulcrum Wheels as the Figure repreſents: and it is further obſervable, that Wheels in turning each other, bearing on each other in different quarters, or, as the ſaid bearings are more or leſs under or over the Plane of the Horizon, will vary the bearing of their Pevets on different quarters of the Groove, Trench, or Socket in which they turn round; and conſequently in order to reduce the Friction, the Pevet Wheels muſt be placed accordingly: in ſhort, if there ſhould be occaſion, the Axis of the Wheel whoſe Friction is to be taken off may turn between four Friction Wheels, that is, one over, one under, and one on each ſide, as the Engineer ſhall ſee occaſion.

C   Example

Example II.

SUPPOSE in Figure 1. of Plate 2. the Pevets of a great Wheel to rest each of them on the Vertex of two Pevet Wheels at a and b, and the Pevets of each of these Friction Wheels to rest on the Top or Vertex of two other Friction Wheels at c and d, and at e and f, the Friction Wheels c and d, and e and f, having each two, one common Axis, and the Diameters of these double Wheels must be a small matter larger than the Diameters of the upper Friction Wheels, in order to prevent the upper Wheel from touching the Axis of the lower double Wheels; and the Axis of each double Wheel is here supposed to rest on the tops of two other single Friction Wheels at g and h, and the Pevets of the latter are supposed to rest on a dead Surface, and their Diameter a small matter larger than the double Wheels, that they may turn clear of the Axis of the lower Friction Wheels; and then suppose the great Wheel to weigh 2000 or a tun, and to be turn'd by the handle at z, at the distance of

2   ten

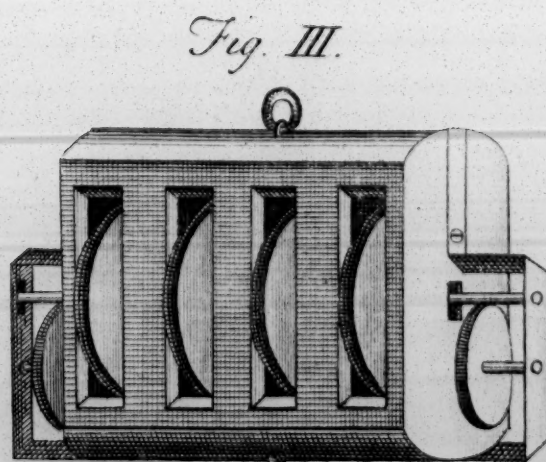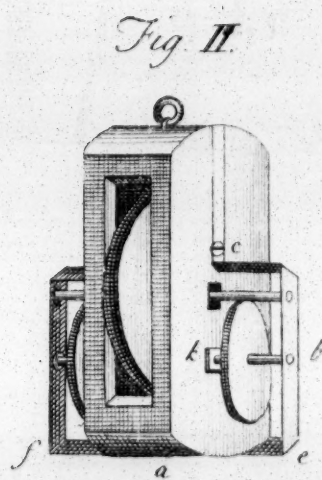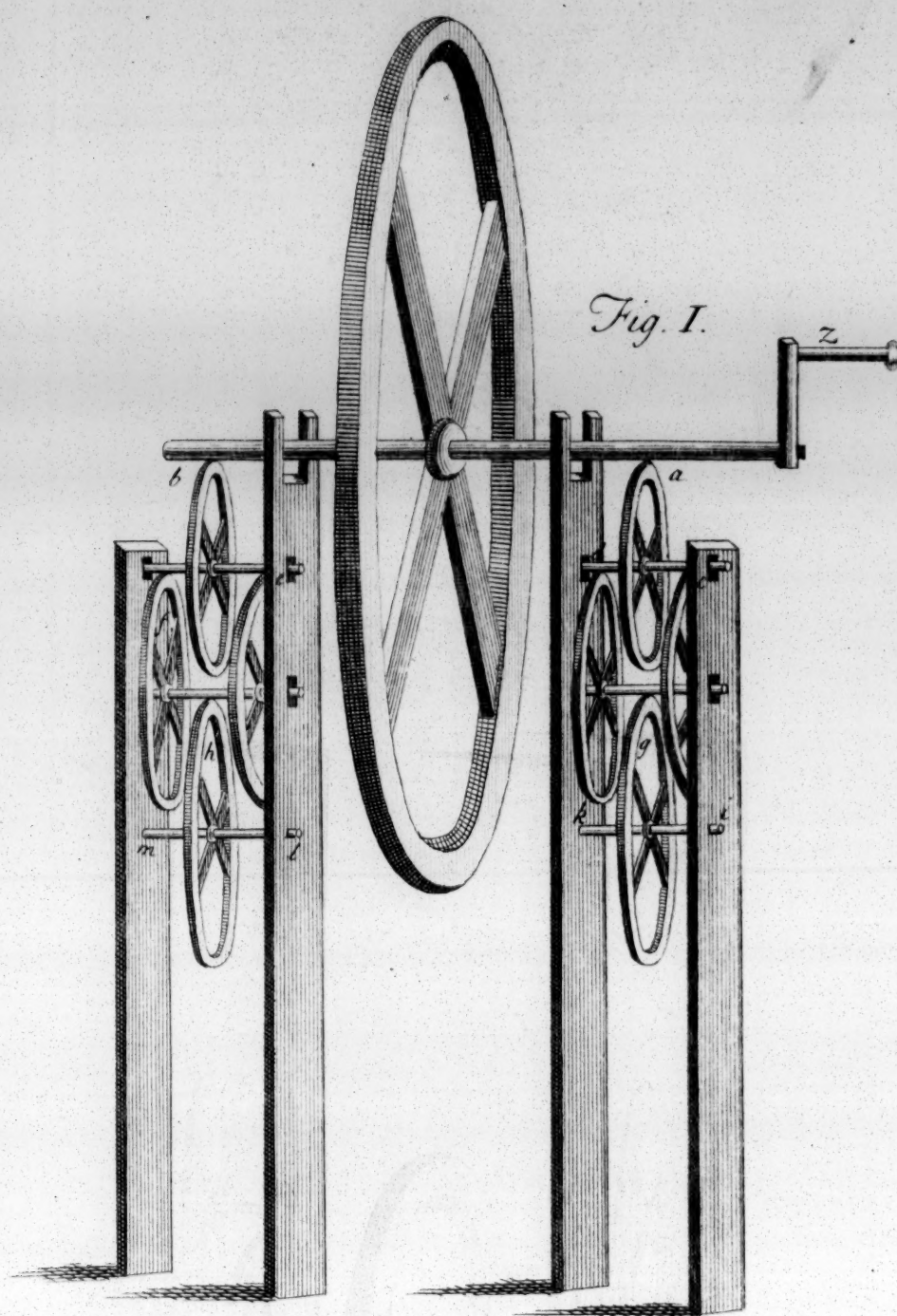Plate. II.ᵈ

Fig. I.

z

b

a

Fig. II.

Fig. III.

Plate. II.^d

ten Semidiameters of the Wheel's Axis from
its Center; and confequently if the Pevets
were to reft on a dead Surface, according to
the firft Chapter, it would require a force of
200 weight to turn the fame; but the great
Wheel being wholly fupported by the Pevets
of the two lower Friction Wheels at *i*, and
k, and *l*, and *m*, on a dead Surface; and in
order to eftimate the diminution of the Fric-
tion, firft the largenefs of each Friction Wheel
muft be duly confidered; that is, how many
times its Axis in the Pevets is contain'd in the
Diameter of each Wheel, which here I will
fuppofe to be twenty times; and then ima-
gine the whole weight of the great Wheel to
reft on the Pevets of one of the lower Fric-
tion Wheels, which fuppofe at *i*, and *k*; fo
that according to the firft Chapter, the faid
Friction Wheel (preffing on its Pevets at the
rate of one tun) a Power acting any where in
its Circumference of a hundred pound will
turn the fame, which Power of a hundred
pound fuppofe to be acted at *g*, by the turn-
ing of the double Wheel's Axis, which Power
of a hundred in the Axis will be generated
any where in the Circumference by a force
of five pound, which force of five pound

C 2   will

ten Semidiameters of the Wheel's Axis from
its Center ; and confequently if the Pevets
were to reft on a dead Surface, according to
the firft Chapter, it would require a force of
200 weight to turn the fame ; but the great
Wheel being wholly fupported by the Pevets
of the two lower Friction Wheels at *i*, and
k, and *l*, and *m*, on a dead Surface ; and in
order to eftimate the diminution of the Fric-
tion, firft the largenefs of each Friction Wheel
muft be duly confidered ; that is, how many
times its Axis in the Pevets is contain'd in the
Diameter of each Wheel, which here I will
fuppofe to be twenty times ; and then ima-
gine the whole weight of the great Wheel to
reft on the Pevets of one of the lower Fric-
tion Wheels, which fuppofe at *i*, and *k*; fo
that according to the firft Chapter, the faid
Friction Wheel (prefling on its Pevets at the
rate of one tun) a Power acting any where in
its Circumference of a hundred pound will
turn the fame, which Power of a hundred
pound fuppofe to be acted at *g*, by the turn-
ing of the double Wheel's Axis, which Power
of a hundred in the Axis will be generated
any where in the Circumference by a force
of five pound, which force of five pound

will

will be performed at *c* and *d*, by turning the Axis of the upper Friction Wheel, which force will be generated in the Axis by a Power of $\frac{1}{4}$ of a pound, acted any where in the Circumference, which force will be generated at *a*, by turning the great Wheel's Axis by a force of but $\frac{1}{40}$ of one pound acted on the handle at *z*, so that by this means of three Friction Wheels turning under the Pevets of the great Wheel, the force of two hundred pound that was required to turn the said Wheel resting on dead Pevets, can now be performed by the force of but $\frac{1}{40}$ part of one pound, which is but the $\frac{1}{8000}$ of 200 ; and consequently if the Wheel instead of two thousand pound had weighed eighty thousand or forty tuns, according to this reduction of the Friction, the said Wheel would be turned by a force (acted on the handle) of but one pound ; so that whatever number of Pevet Wheels are proposed in order to reduce the Friction, it will be very easy to determine how far the said Friction is reduced thereby by the following rule.

Viz. First find the Ratio or Quotients of the Diameter of each Friction Wheel divided by

by the Diameter of its Axis in the Pevets, and then (if but one Friction Wheel is concerned, the Quotient will be the Denominator of a Fraction) multiply the said Quotients one into another, and the last product will be the Denominator of a Fraction, whose Numerator must be the great Wheel's Friction, supposing its Pevets to turn on dead Surface; that is, here in this example the Friction of the great Wheel by the first Chapter is two hundred pound, and the Quotient of each Pevet Wheel, divided by the Diameter of their Axis, is twenty, which multiply'd one into the other, produces eight thousand for the Denominator; whose Numerator is two hundred, which Fraction is $\frac{200}{8000}$, which reduced to its lowest Denomination is $\frac{2}{80}$ or $\frac{1}{40}$ of one pound.

REFLECTION.

By this method of reducing the Friction by means of several little Pevet Wheels, we avoid the charges of two very large Wheels. As for instance; suppose the aforenamed Friction Wheels were each of them twenty inches

2   Diameter,

Diameter, and the Diameter of their Axis in the Pevets is one inch, then by the foregoing rule the Friction (by multiplying the Quotients one into another) is reduced thereby, the same as if the Pevets of the great Wheel were to turn on two Friction Wheels of eight thousand inches Diameter, which is equal to six hundred and sixty six foot, an impracticable largeness for one Wheel; or by a number of these Friction Wheels, the advantage is the same as if it were possible to cause the great Wheel to turn on an Axis, no greater than the smallest needle, or very small wire: And consequently Engines compos'd of the largest and most heavy Wheels will now be exercised by very small Powers; that is, the most simple Engine will require a third less Power than usual, which will be a great saving of charges where many Wheels are concerned: And further, where many Friction Wheels are concerned turning one under the other, accidental Friction seems to vanish, being no more able to obstruct, but in the Pevets of the two lower Wheels.

COROLLARY

COROLLARY I.

ALL Pullies and all forts of Blocks ufed at Sea may have the Friction of their Trucks or Sheaves greatly diminifhed by one fingle Friction Wheel lying under each Pevet of their Axis, of which I fhall give examples of the moft practicable methods of performing the fame.

EXAMPLE I.

To take off the Friction of the Truck of any fingle Block.

IN all Blocks, in order to leffen the Friction of their Trucks, the wood part or body thereof may be in the form of an Oblong, with the corners made round, and the fides truly flat, as appears in Figure 2. of Plate the 2d; which Blocks, and all others for this purpofe, I propofe to be ftrap'd with Iron, or to be circumfcribed with an Iron Plate, with two Joynts, at *e* and *f*, to be faftened

ened with a Screw at the end of the Block at
a, and on the Sides, whereby the Block will
be kept steady in the Strap, and the Strap
must project a convenient distance from each
side of the Block, on that end opposite to the
Strap or Loop-end of the Block, in order to
give room for the Friction Truck or Wheel
to turn freely on each side thereof; which
Friction Wheel must have one of its Pevets
to turn in the Iron Strap, as at *b*, and the o-
ther in a metalick Nut fixed on the side of
the Block, as at *k*: And the Diameter of the
said Friction Wheels or Trucks I propose to
be about half the Diameter of the Truck in
the Block, and the said Trucks to be applied
in making any great Purchase may be of cast
Iron, or of Brass, or for common service they
may be of Wood ; but then the Friction
Trucks must be hoop'd with Iron, and their
Axis, together with the Axis of the great
Truck or Trucks in the Block, must be made
of good wrought Iron, and the ends thereof
may be pointed with Steel ; and the Axis passing
through the Block should be made round and
just, exactly to fit the Hole in the Truck,
which on each side thereof must have Col-
lars for keeping it steady, and from rubbing

on

on either fide of the paffage; and that the said Axis may have no other rubbing or dependance than on the Friction Trucks, the hole in the Blocks muft be bored fomething larger than the Diameter of the Axis, which muft pafs through the Block, and each end thereof muft bear on the top of each Friction Truck, and muft be continued long enough, juft to touch the infide of the Iron Strap, where it muft turn between two Cheeks, ferving as Fulcrums to the Axis, in order that the motion may be exactly fteady, and to prevent the wearing any part of the Block.

EXAMPLE II.

To take off the Friction of the Trucks of double, treble, or quadruple Blocks, &c.

LET Figure 3. in Plate 2. reprefent a Block having four Trucks, which Block muft be made with partitions between each Truck as common, in order to prevent the Rope from flipping on one fide or the other; which Block, for the fame reafon given in the firft Example, muft be bored through with an

D   Augur

Augur fomething larger than the Axis; and the faid Axis before it is drove through muft be made exactly to fit each Truck, and muft come through the Block as beforementioned, to reft on the top of the Friction Wheels, which, together with the Iron Strap, muft be in every refpect the very fame as defcribed in the firft Example; fo that the four Trucks muft have one common Axis, which will turn round with the Trucks, which it will likewife do even if the faid Trucks fhould chance to wear loofe on the Axis; all which methods will be performed with the leaft trouble and the leaft expence; and may be applied with great advantage and eafe of Power to all forts of Tackles, Snatch Blocks, Jear Blocks, &c. and all kind of Blocks where their largenefs and weight may not be objected againft; which will be of particular advantage to all Merchant Ships that covet to fail with the feweft hands.
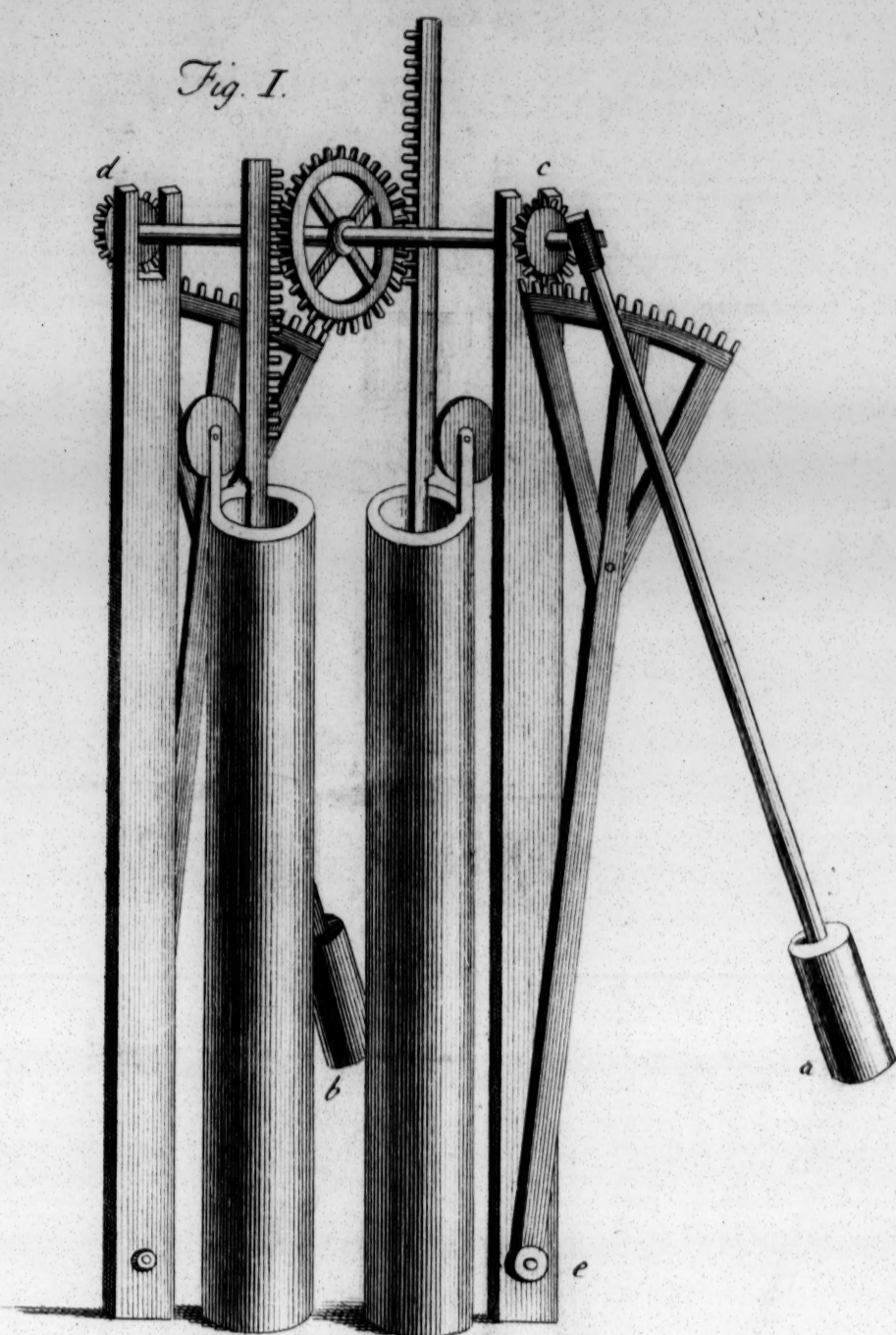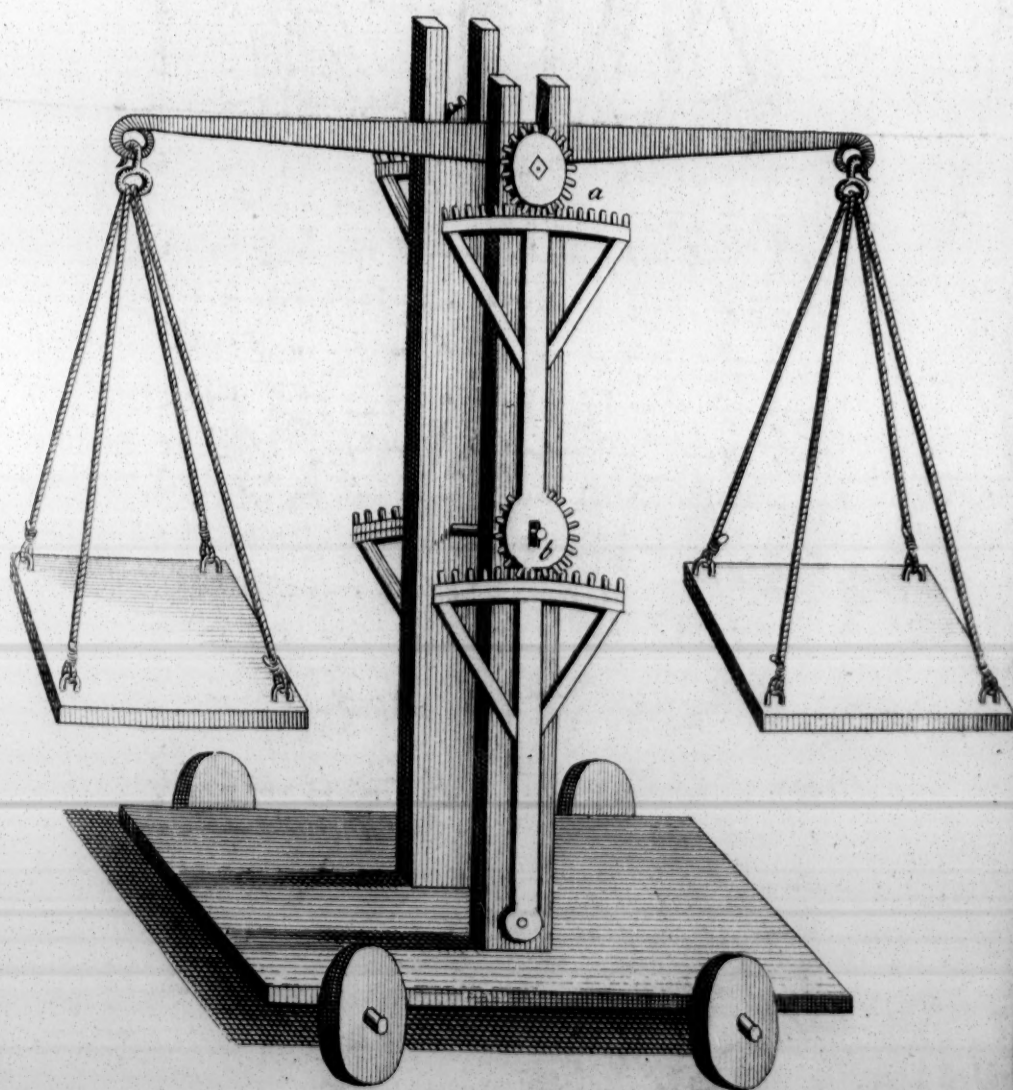
COROLLARY

Plate. III^d

Fig. I.

d   c

b

a

e

Fig. II.

a

b

COROLLARY II.

Concerning all vibrating Motions.

ALL vibrating Motions, such as the Pen-
dulum and the Balance, not requiring
their Axis to turn quite round, may have the
Friction of their Pevets reduced to the loweſt
degree of perception without the uſe of Fric-
tion Wheels, or inſtead thereof, the Axis of
the Pendulum or of the Balance may turn on
a ſmall Sector of a Circle; and the Center
end of the ſaid Sector may reſt and turn on
the Arch of another Sector, and ſo on till
the Friction ſeems quite to vaniſh; whereby
a Balance may break with the leaſt quantity
of Matter that can be perceived, &c.

EXAMPLE I.

*Of diminiſhing the Friction of a Pendulum by
the application of a ſingle Sector.*

FIgure 1. of Plate 3. repreſents a double
Pendulum with a Wheel fixed in the

middle

middle of its Axis for working of two Pumps by two Cranks fixed on the Pump Spears, as the Figure reprefents; and this Pendulum is fuppofed to be loaded on the ends thereof at *a* and *b*, and the ends of the Axis at *c* and *d*, have each of them a little Wheel fixed thereon, which little Wheels muft reft on and turn on the Arches of two Sectors divided into Teeth for that purpofe: And that the Friction of the Pendulum's Axis may be moft effectually taken off, the Radius of each Sector fhould be full the length on the Stands on which the Pendulum doth vibrate, fo that the Center of each Sector muft be fixed at the lower end of each Stand as appears at *e*; and the fame may be fuppofed on the other fide, whereby the Friction of the faid Pendulum is as effectually taken off, as if the Pevets of its Axis were to turn on the Vertex of two large Wheels, whofe Radius is equal to the Radius of the Sectors, which Wheels would take up much room, and in reference to the Sectors will be very chargeable.
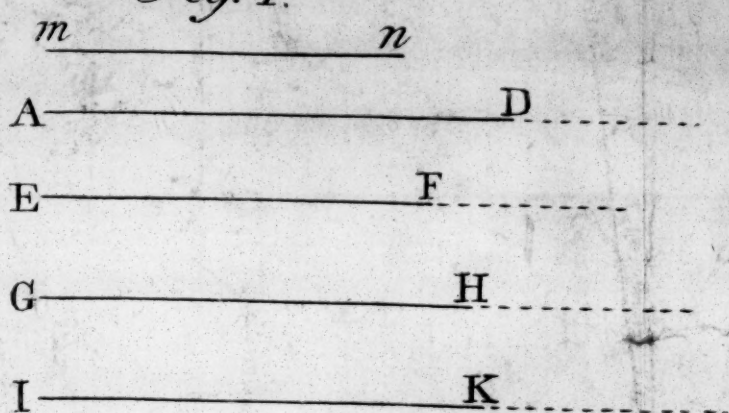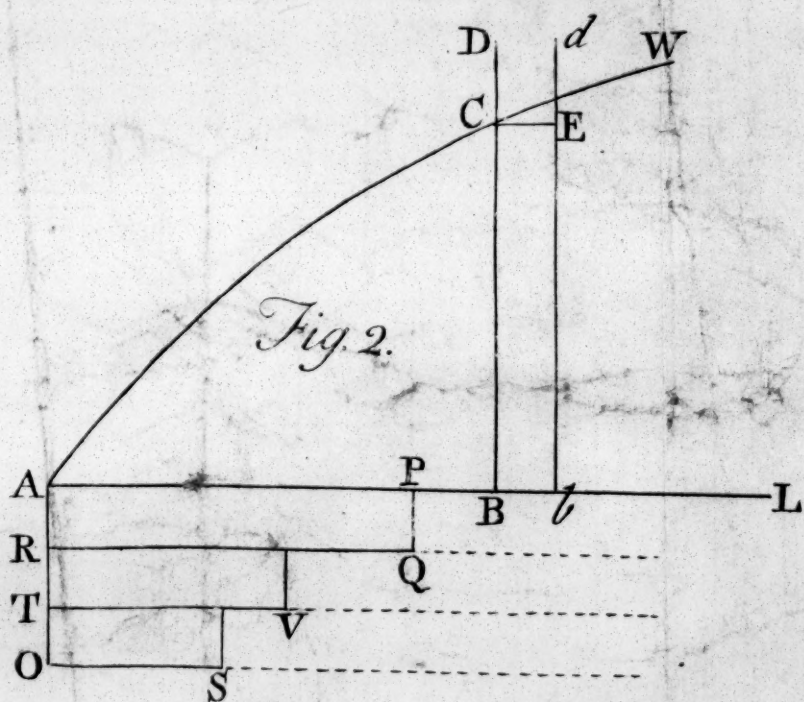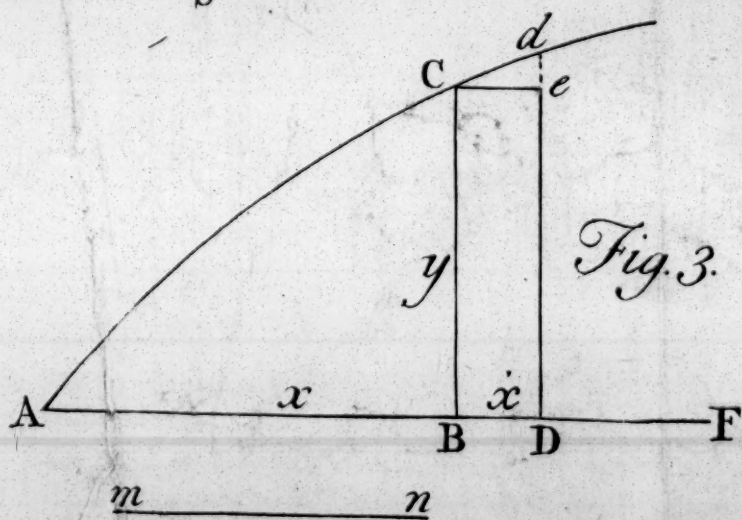
EXAMPLE

Fig. 1.

m ———————————— n

A ——————————————— D - - - - - - -

E ——————————————— F - - - - - - -

G ——————————————— H - - - - - - -

I ——————————————— K - - - - - - -

Fig. 2.

D   d   W

C   E

A   P   B   b   L

R   Q - - - - - - - -

T   V - - - - - - - -

O   S - - - - - - - -

Fig. 3.

C   d
e

y
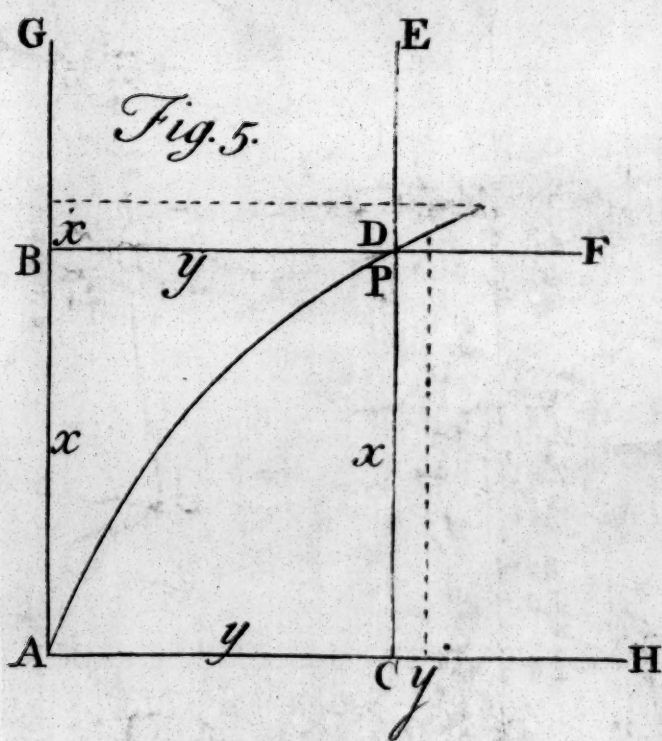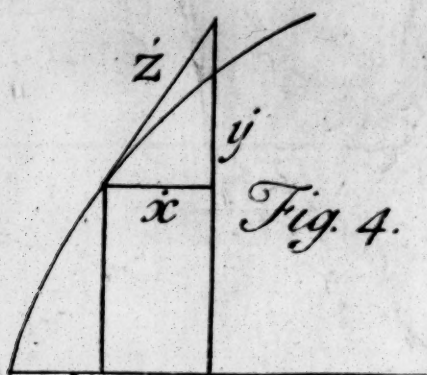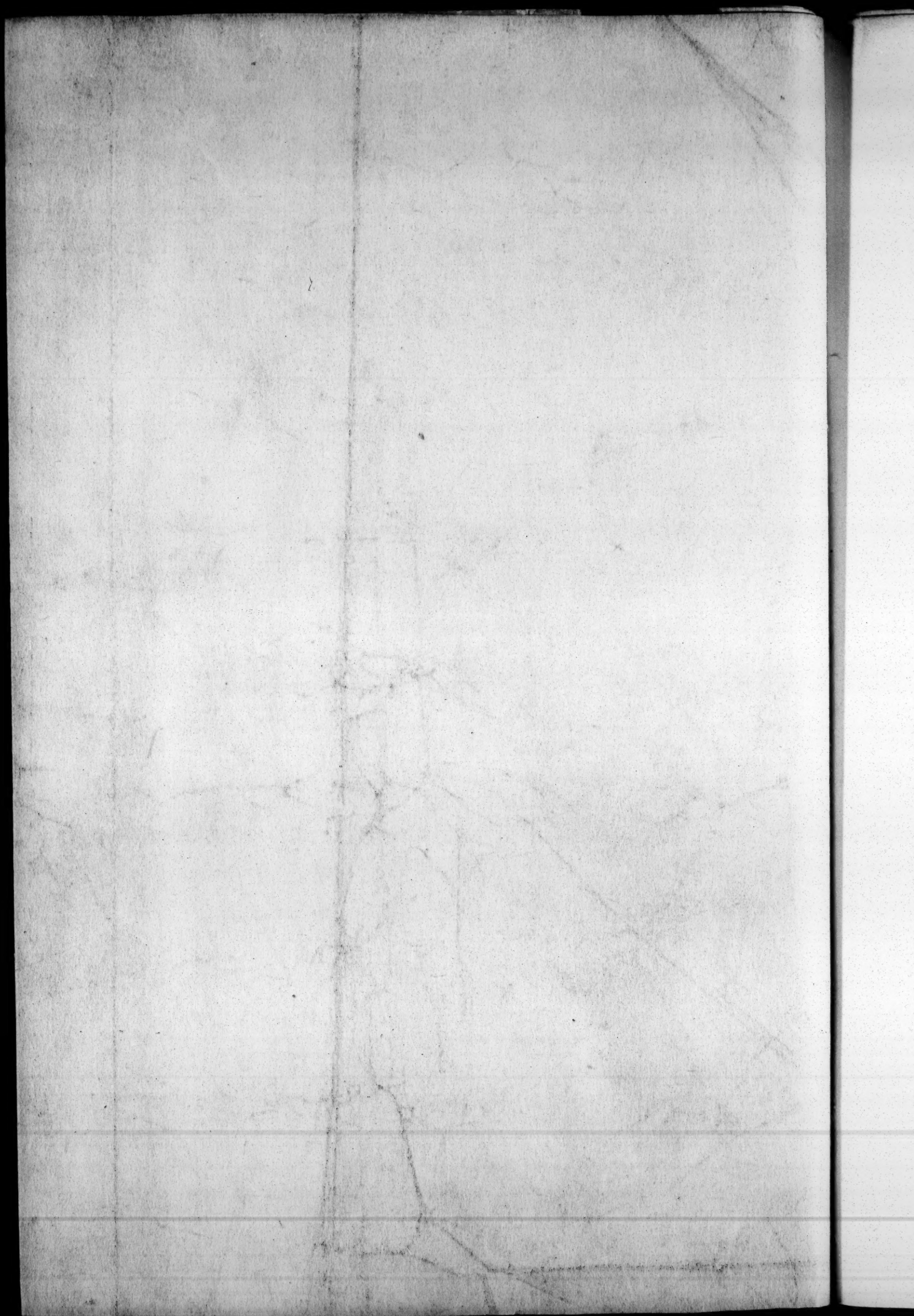
A   x   B   x   D   F

m ———————— n

Fig. 4.

Fig. 5.

Example II.

FIgure 2. of Plate 3. reprefents a large Mer-
chant's Scale or Balance for weighing of
bulky or heavy Goods, which Scale, for the
more convenient moving it from place to
place, may have four Trucks fixed on the
bottom Plank or Board : And there muft be
a paffage between the upright Stands or Beams
large enough for the Beam of the Balance to
vibrate up and down ; which Balance Beam
I fuppofe to be eight foot in length, and to
move on an Axis of one inch Diameter, hav-
ing little Wheels fixed on the Pevets or Ends
of the faid Axis of two inches Diameter, to
admit of being divided or cut in their Cir-
cumference, in order to receive the Teeth
cut in the Arch of the Sectors, as appears at
a, (and may be imagined the fame on the
other fide of the Stand) the Radius of which
Sector I propofe to be half the length of the
Stand which is here fuppofed feven foot, fo
that the Radius of the faid Sector will be
three foot and half, which is to reft and turn
on the top of another Sector of the fame Ra-
dius,

dius, by means of a little Wheel fixed on the end thereof of two inches Diameter (the fame as on each end of the Axis) which little Wheel muft have a hole through its Center for an iron Pin to come through from the Stand where it muft be fixed, to ferve as a Fulcrum for the Sector; fo that the hole muft be cut longways, that the Sector may have no other refting place than on the top of the other Sector, as appears at *b*; and laftly, the lower Sector muft turn on its Axis refting on a dead Surface, which Axis I propofe to be fix tenths of an inch Diameter; and by a fmall number of thefe Sectors placed in this manner under each other, the Friction of any Balance will be imperceptible, as may be eafily underftood by the following calculation.

Viz. Suppofe with this great Scale it was demanded to weigh a hundred pound weight of filver, and to know what quantity of weight will break the Scale from one fide to the other, when brought to a Balance with the aforefaid weight: To know which, firft it muft be confidered that the Axis will then prefs on its Pevets at the rate of two hundred pound Troy, or two thoufand four hundred

6   ounces:

ounces : And according to the firſt Chapter, the acting diſtance being four foot, containing forty eight Semidiameters (being one inch) of the Axis, the Friction thereof (ſuppoſing the Axis to turn on a dead Surface) is equal to fifty ounces; but the Ratio between the upper Sector being forty two inches, and the Radii of the little Wheel being one inch, gives forty two for the Quotient; and the Ratio of the ſecond or the lower Sector being three foot and half, or forty two inches long, and the Semidiameter of its Axis being but three tenths of an inch, the Quotient is a hundred and forty, which Quotients multiplied one into the other, gives 5880 for the Denominator, having fifty ounces; the dead Friction for the Numerator or $\frac{50}{5880}$ or $\frac{5}{588}$, which demonſtrates that four grains and .08 of one grain is ſufficient to break the Balance, when a hundred pounds Troy is contained in each Scale, which method of cancelling the Friction will be uſeful in all other vibrating Motions, too many to be here enumerated.

COROLLARY.

COROLLARY III.

Concerning the Method of cancelling the Friction of all Wheel Carriages.

FROM the difcovery of cancelling the Friction of any Wheel, great advantages will accrue thereby in all Wheel Carriages; for the whole weight of the Coach, Cart or Waggon, &c. bearing on the Pevets of their Wheels, the faid Wheels have no other difficulty or obftruction to hinder their turning round, than what is occafioned by the Friction of their Pevets, which will confequently be more or lefs, according to the weight of the Coach, Cart or Waggon preffing thereon; which having no other effect than if the Wheels were loaded in their Circumference with the aforefaid weight of Coach, Cart or Waggon, the Obftruction or Friction caufed thereby, or the Draught that will be enquired of the Horfes on a Plain, will be limited by the rules given in the firft Chapter, and the fame will be diminifhed or cancelled by the methods in the fecond Chapter, which

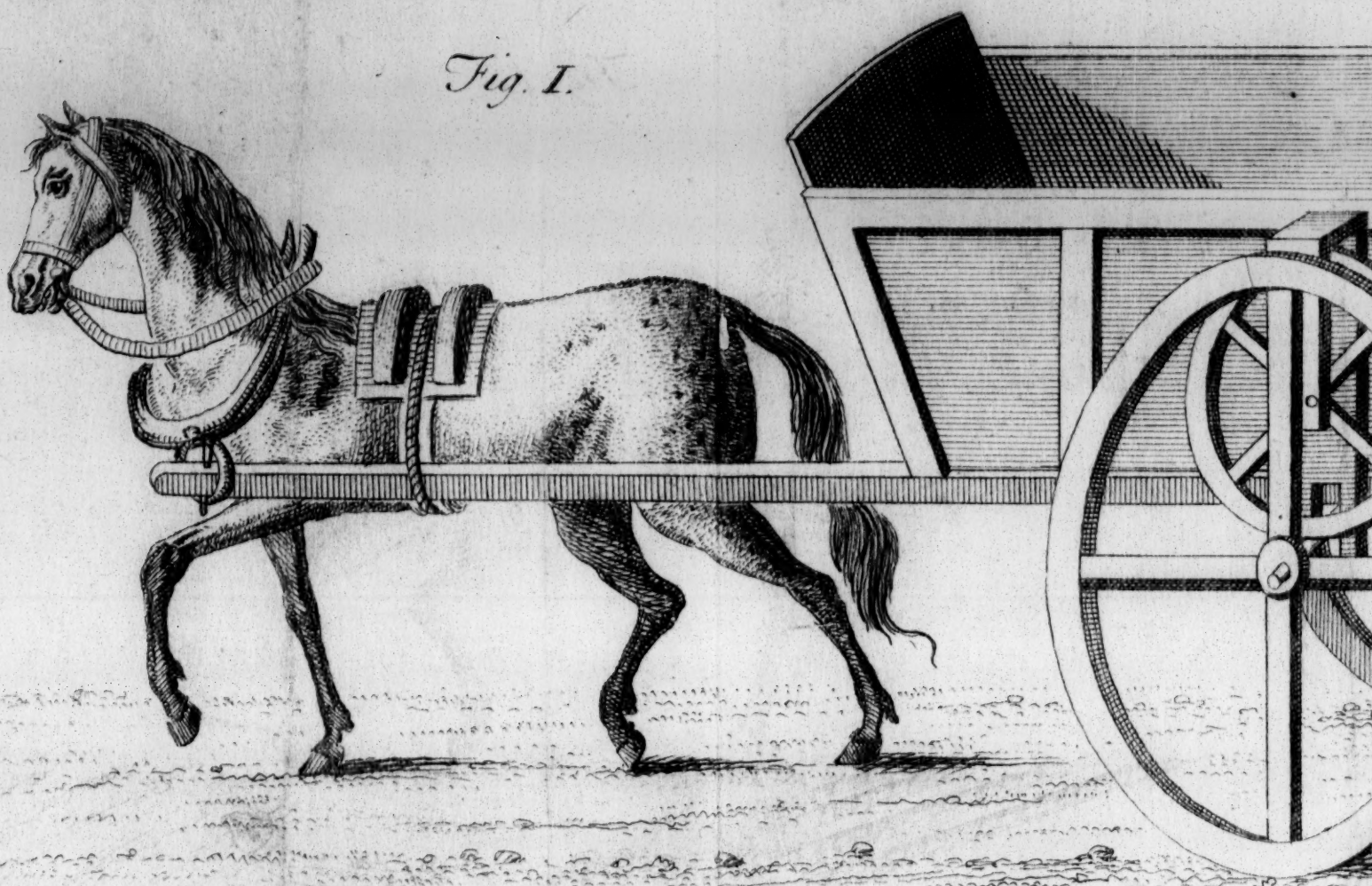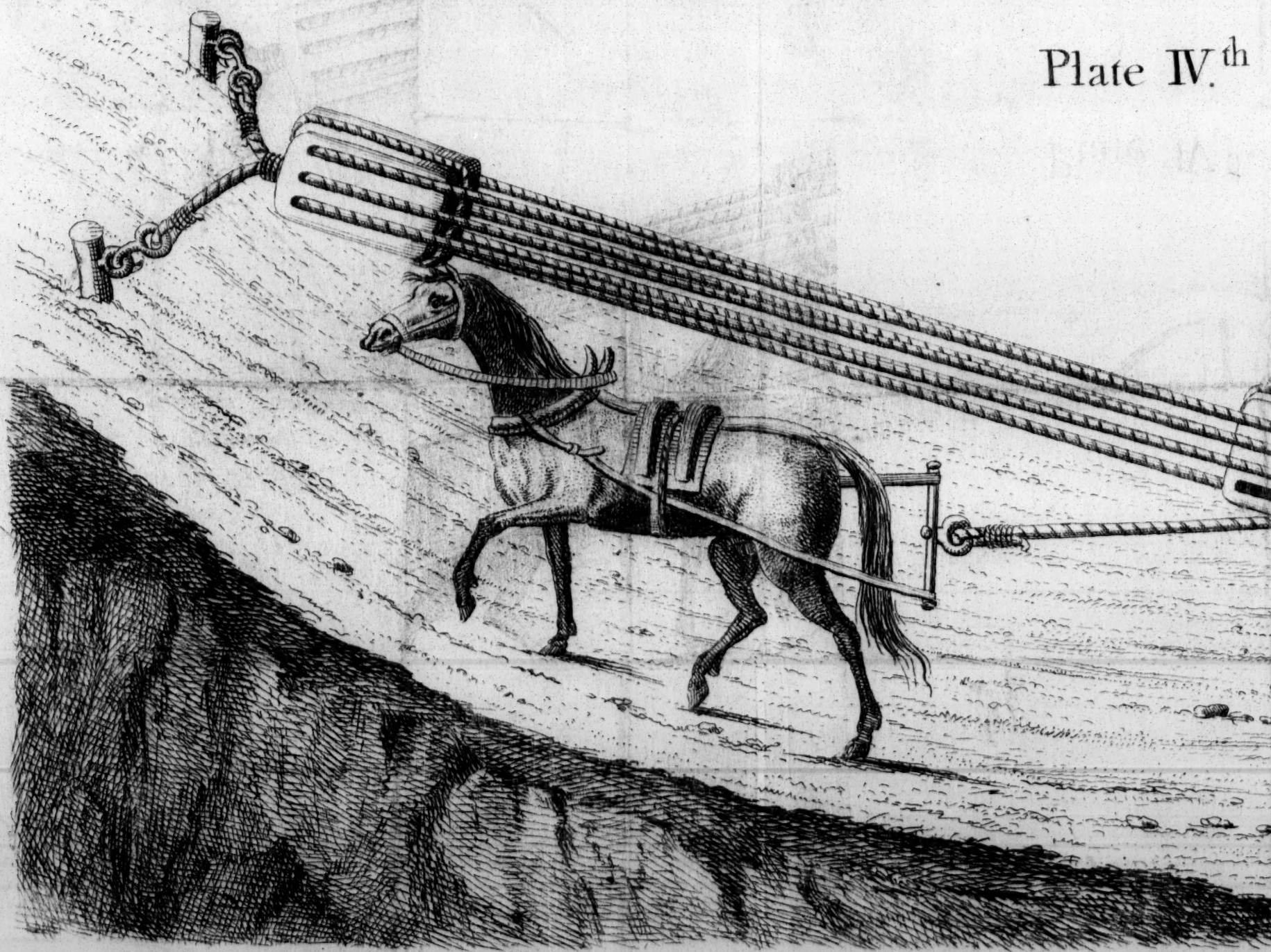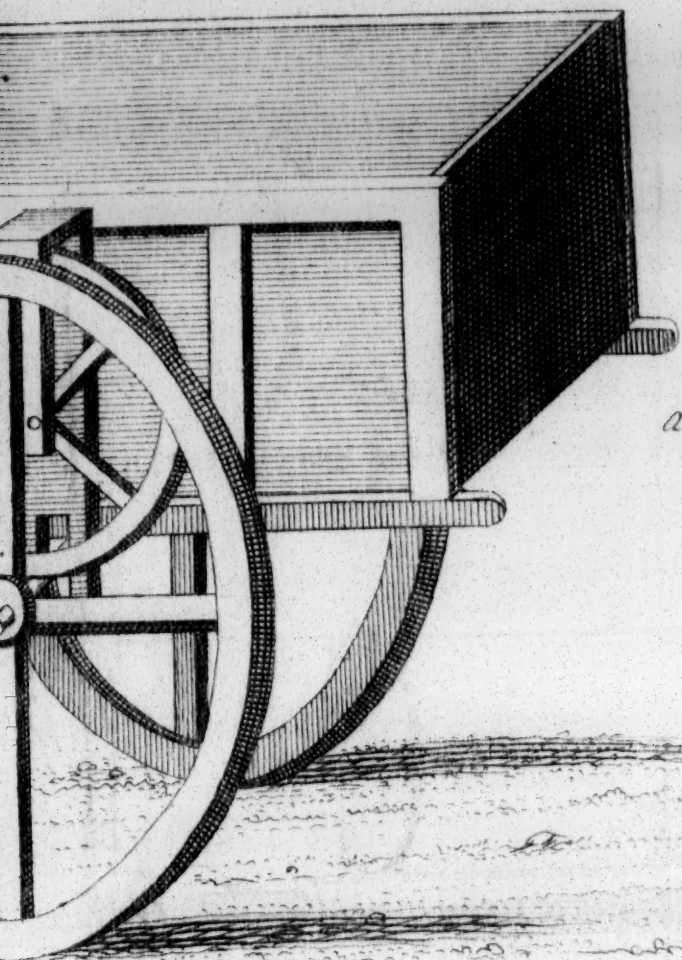I   may
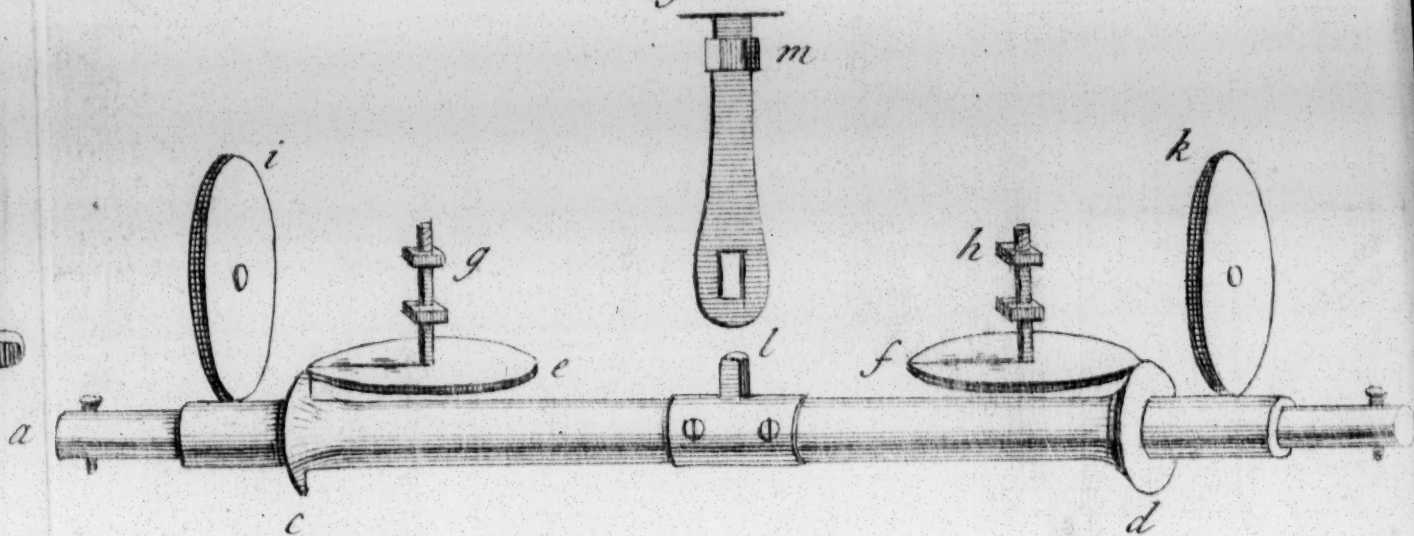
Fig. I.

Plate IV.th
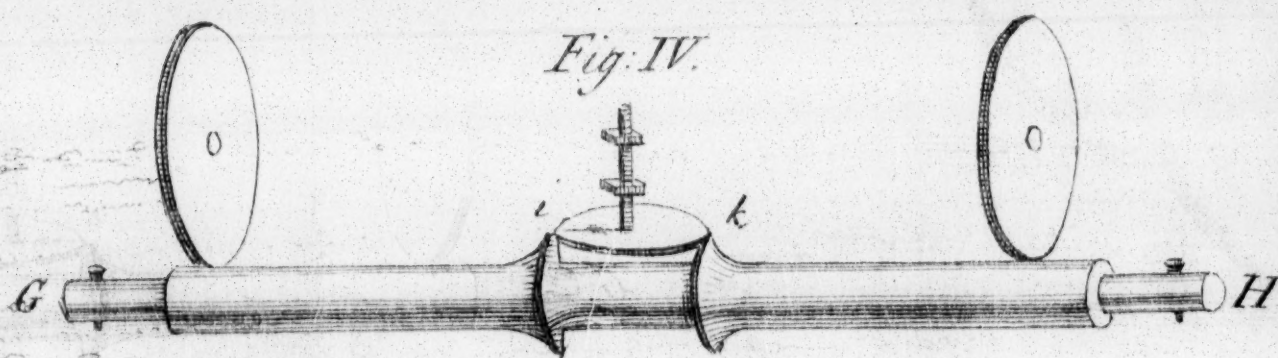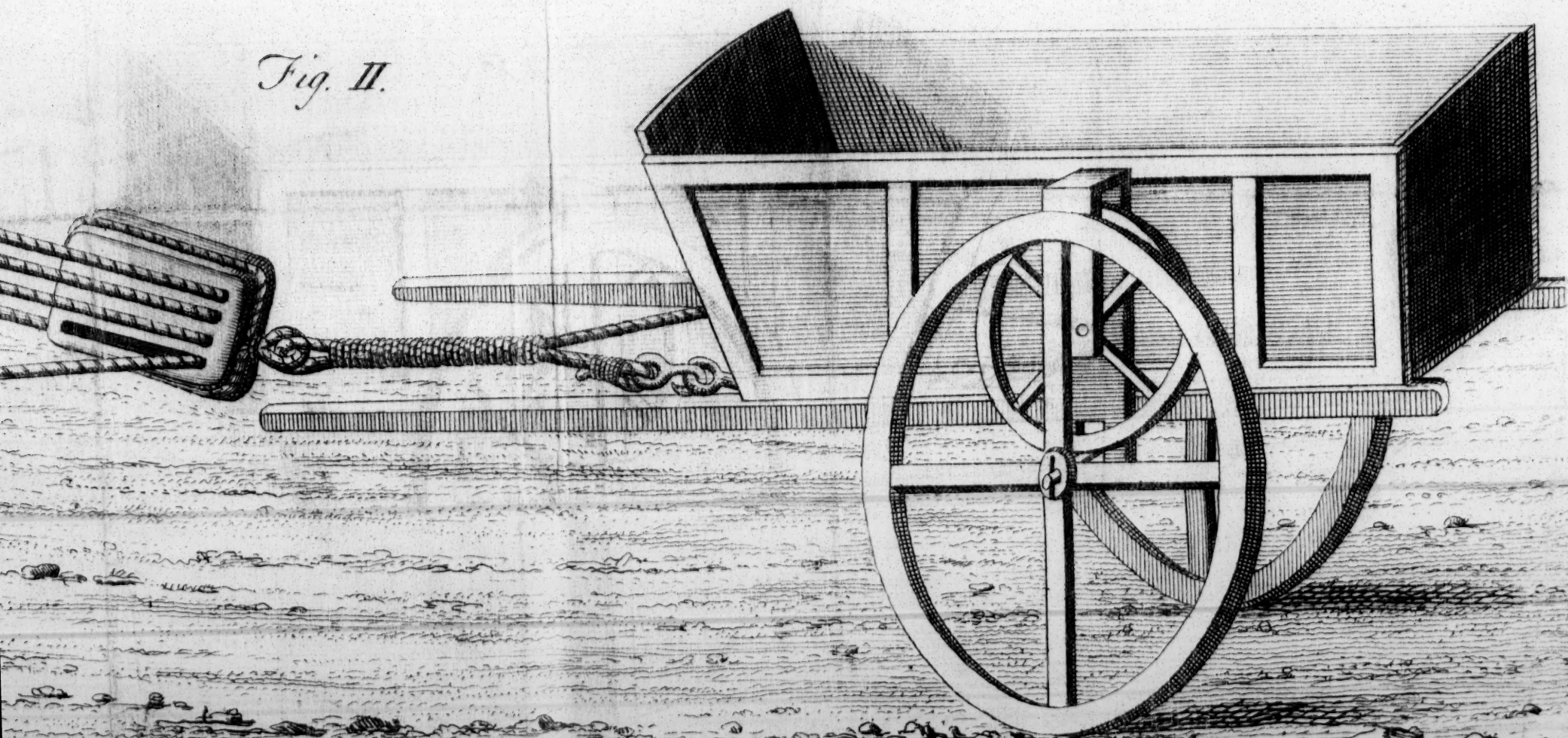
Fig: III.

m

i

g

k

h

a

c

e

l

f

d

Fig: IV.

i

k

G

H

V.th

Fig. II.

may be clearly underſtood by the following example; ſhewing the manner of taking off the Friction of the Wheels of a Country Dung-Cart, in which manner it is propoſed to take off the Friction of any other Wheel Carriage.

EXAMPLE.

IN order to cancel the Friction of the Wheels of any Wheel Carriage, the Wheels muſt not only turn on the ends of their Axis as uſual, but the Axis muſt alſo turn with the Wheels; and the ſaid Axis, to avoid any Friction by the turning thereof, muſt not touch any part of the ſides or bottom of the Machine, but only muſt bear on the Nadir Points of two little Wheels, which muſt be fixed to the ſides of the Cart or to the Carriage of any Coach, Chariot, &c. which Friction Wheels muſt turn between two Cheeks of Wood, having one end of its Axis to turn in a Nut fixed on the inner Cheek, and the other in the outer; ſo that in reality the ſaid

E   Axis

Axis of the Friction Wheels muſt bear the whole weight of the Cart, &c. and the Load contained therein reſting laſt of all on the top of the great Wheel's Axis, which may be ſeen at *a*, in Plate 4, Figure 1; and the ſame is to be imagined on the other ſide of the Cart. The Diameter of the Friction Wheels or Trucks for common uſes need not exceed two foot; and their Axis, which ſhould be of iron, need not exceed an inch Diameter in the Pevets, whereby on a Plain a Horſe will be able to draw about twenty four times greater Load than common, which will very much leſſen the expence of the Carriage of all heavy Goods, &c. and will be of particular ſervice in the Artillery, in ſuch Carriages where heavy Cannon is required to be drawn, where it would be requiſite to apply two Friction Wheels to each Pevet of the great Wheel.

REFLECTIONS.

A TABLE, shewing, by means of the Golden Numbers, the several Days on which the Paschal Limits or Full Moons, according to the *Gregorian* Account, have already happened, or will hereafter happen; from the Reformation of the Calendar in the Year of our Lord 1582, to the Year 4199 inclusive.

To find the Day on which the Paschal Limit or Full Moon falls in any given Year; Look, in the Column of Golden Numbers belonging to that Period of Time wherein the given Year is contained, for the Golden Number of that Year; over-against which, in the same Line continued to the Column intitled *Paschal Full Moons*, you will find the Day of the Month, on which the Paschal Limit or Full Moon happens in that Year. And the *Sunday* next after that Day is *Easter* Day in that Year, according to the *Gregorian* Account.

Golden Numbers from the Year 1583 to 1699, and so on to 4199, all inclusive.

Paschal Full Moons — Days of the Month, and Sunday Letters	1583 to 1699	1700 to 1899	1900 to 2199	2200 to 2299	2300 to 2399	2400 to 2499	2500 to 2599	2600 to 2899	2900 to 3099	3100 to 3399	3400 to 3499	3500 to 3599	3600 to 3699	3700 to 3799	3800 to 4099	4100 to 4199
March 21. C	3	14			6		6	17	9		1	12	1	12		4
22. D		3	14					6	17	9		1		1	12	3
23. E	11		3	14		14			6	17	9		9		1	12
24. F		11		3	14	3	14			6	17	9	17	9		1
25. G	19		11		3		3	14			6	17	6	17	9	
26. A	8	19		11		11		3	14			6		6	17	9
27. B		8	19		11		11		3	14					6	17
28. C	16		8	19		19		11		3	14		14			6
29. D	5	16		8	19	8	19		11		3	14	3	14		
30. E		5	16		8		8	19		11		3		3	14	
31. F	13		5	16		16		8	19		11		11		3	14
April 1. G	2	13		5	16	5	16		8	19		11		11		3
2. A		2	13		5		5	16		8	19		19		11	
3. B	10		2	13		13		5	16		8	19	8	19		11
4. C		10		2	13	2	13		5	16		8		8	19	
5. D	18		10		2		2	13		5	16		16		8	19
6. E	7	18		10		10		2	13		5	16	5	16		8
7. F		7	18		10		10		2	13		5		5	16	
8. G	15		7	18		18		10		2	13		13		5	16
9. A	4	15		7	18	7	18		10		2	13	2	13		5
10. B		4	15		7		7	18		10		2		2	13	
11. C	12		4	15		15		7	18		10		10		2	13
12. D	1	12		4	15	4	15		7	18		10		10		2
13. E		1	12		4		4	15		7	18		18		10	
14. F	9		1	12		12		4	15		7	18	7	18		10
15. G	17	9		1	12	1	12		4	15		7		7	18	
16. A	6	17	9		1		1	12		4	15		15		7	18
17. B		6	17	9		9		1	12		4	15	4	15		7
18. C			6	17	9	17	9		1	12		4		4	15	
19. D	14			6	17	6	17	9		1	12		12		4	15
20. E																
21. F																
22. G																
23. A																
24. B																
25. C																

REFLECTIONS.

IT cannot be expected that the advantage gained in leſſening the Draught of Horſes can fall preciſely under the rule given in the ſecond Chapter, except on plain and hard ground, but (by taking off the Friction) on rugged and dirty roads, and according as the ſaid dirt is more or leſs ſtiff or clay-like, the advantage that was before gained will be very much abated: And it will be more conſiderably ſo in going up ſteep Hills; where in going up a Hill of the common ſteepneſs reckoned practicable for Wheel Carriage, it has appeared by experiment, that a Horſe which on plain ground could draw twenty four times more than common, could not draw more than double the uſual Load in going up ſuch a Hill; that is, the ſteeper the Hill, the leſs weight will reſt on the Wheel's Pevet, and the remaining weight will draw back againſt the Horſes; ſo that to know the true Draught that will be required in drawing up a ſteep Hill, it muſt be conſidered at what

E 2 rate

rate Gravity will draw againſt the Horſes,
and then the Friction of the remaining weight
muſt be calculated according to the Rules in
the firſt and ſecond Chapter, which obſtruc-
tion by Friction muſt be added to the weight
that Gravity draws down Hill, which Sum
will limit the true Draught that muſt then be
performed by the Horſes; ſo that when the
Hill is of ſuch a ſteepneſs as for Gravity to
pull back at the rate of half the weight of
the Machine, it will then require two Horſes
in the ſtead of three, that may be required
according to the common way of Drawing,
without cancelling the Friction; which miſ-
fortune and charges in requiring ſuch exceſs
of Power in drawing up Hill, is too viſible to
all that make uſe of Wheel Carriages; and
therefore it may not be impertinent to make
mention of the common ſhifts that are made
by countrymen on this occaſion, *viz.* in draw-
ing of Stones, Marle, Coal, and various dreſ-
ſing and gooding for Land, they cauſe ſeve-
ral Carts, Wains, *&c.* to go in company, in
order when they come to a ſteep Hill or a
Bank to apply the whole number of Horſes
(if occaſion ſhould be) to one Cart, *&c.* till
the

the whole number of Carts, &c. are drawn
up the said Hill or Bank; but lest one Man
should not be able to employ many Horses,
or that neighbours may not agree to assist
each other, it will be necessary to propose some
other expedient.

Viz. In Figure 2. in Plate 4. suppose B to
be on the top of a steep Hill or a Bank adja-
cent to a Quarry, and a Cart to be at the
bottom thereof, which with a heavy Load
may not be practicable in the common way
to be drawn up, I say then in such a case it
will be necessary to make use of a Wind-
tackle, or a Winding-tackle, the which must
be fastened, the one end to the Cart, and the
other end at B, on the top of the Hill to a
Post, or two Posts on each side of the Road,
drove into the ground for that purpose (which
may also be done at any other bad step in
the Roads) and then the Horse or Horses
clapt to or made fast to the Fall, will be able
each single Horse to draw as much as a large
Team; and still the more to obviate the said
Draught, the Blocks of the said Tackle may
have the Friction of their Trucks taken off, as
before

before directed, which Tackle will be but of
small charge, will laft long, and will take up
but little room in Carriage ; and I fhall only
add, that where fuch Pofts are not drove,
their ufe may be fuddenly fupplied by carry-
ing a pair of iron fpiral Screws, with eyes in the
fame for taking in a Hook, which Screws be-
ing like that of a Cooper's, may eafily be
fcrewed into the ground, remembring to fcrew
them in a ftreight Line with the Draught or Car-
riage. And before I conclude, it may be proper
to make mention of the reafon why I propofe
the great Wheels to turn on the ends of the
Axis as ufual, and not to be fixed thereto,
which indeed is of no ufe, but only when the
Coach, Chariot, &c. is to make a fhort turn
from one Street or Lane into another, or fud-
denly to crofs a Road ; for then if the Wheels
were fixed on their Axis they could not turn
round, but would drag on the ground, which
would be a great ftrain to the Off-Wheel, and
alfo to the Horfes ; whereas they being made
to turn on the ends of their Axis, the Off-
Wheel will be able to turn while the other
ftands ftill, or one can be turning forward
while the other is going back ; and laftly,

5

in

in going up a steep Hill, that the Horses may not be affected by the Machine's drawing back, a little Wheel is fixed on the Axis with two Palls or Catches, as occasion shall require, the one let fall in going up Hill, the other in going down, to prevent the Horses from being press'd forward; or in common labour a Drag may be used going up Hill, and in going down, one of the hind Wheels may be lash'd, or hindered from turning as usual.

ADVER-

ADVERTISEMENT.

ON trial of a Coach full of People, having the Friction of the Wheels taken off, as before explained (which was performed by two ordinary Horses travelling full thirty six miles in a bad road, within the space of seven hours) I found where the road was even that the Braces were scarce ever seen to be drawn tight; but on the Coach's leaning considerably on one or the other side, the Draught of the Horses did appear to be considerably greater, the which was occasioned purely by the rubbing of the Shoulders of the Axis on the Cheeks, there being then a dead Bearing or Surface ; and therefore I contrived a remedy for the said Obstruction in the manner as follows.

Viz. Suppose (in Plate 4, Figure 3) *a b* to represent the Axis of any two Wheels belonging to any Coach, Chariot, Cart, *&c.*

a and

and the perpendicular Friction Wheeels for taking off the Friction of the said Axis, occasioned by any Weight that presses right downward, is represented by *i* and *k*, and the Friction Wheels moving horizontally at *e* and *f*, serve to take off the Friction of the Shoulders of the Axis at *c* and *d*, that is, whenever the Coach, *&c.* does happen to lean on either side ; which suppose towards *b*, then will the Shoulder at *c*, bear hard on the Friction Wheel at *e*, which will turn round with the same, while the other Shoulder at *d*, will have no bearing ; or the said Shoulders (at *c* and *d*) if it should be thought most convenient, may as well be placed on the other side of the horizontal Friction Wheels (at *e* and *f*). And further, as a saving of charges, one horizontal Wheel may supply the use of two, as appears by the Axis *G H*, in Figure the fourth, where the said Wheel turns between two Shoulders at *i* and *k*, which Shoulders in this case will be most conveniently placed in the middle of the Axis ; in the same manner as may likewise be seen at *c d*, Figure the second of Plate the fifth, being the Draught of a Coach,

F where

where *A* is fuppofed to be the hind and *B*
the fore perpendicular Friction Wheels; the
firft is propofed to be about two Foot Dia-
meter, and the other to be one Foot and a
half, both of which may be made of Wood,
and hoop'd with Iron, with Iron Axis's, and
their Pevets to turn in Bell-Metal Nuts or
Coggs; but the Horizontal Wheels being
but fmall are propofed to be of caft Iron,
Brafs, or Bell-Metal; and to prevent their
clogging with the Dirt of the Roads, they may
be covered with Leather, or be cafed with
thin Wood.

Figure the firft of Plate the fifth, fhews
the form of a Waggon, by which Figures,
together with that of the Cart, it is eafy to
judge of the nature of all other Wheel Car-
riages on this principle, and therefore needs
no other examples; only it will be neceffary
to obferve, that the Axis of the Great Wheels,
when their Pevets wear loofe in the Nave, will
require thereby an encreafe of Power to draw
the Machine, occafioned by the Weight that
lies on the top of the Axis at certain intervals,
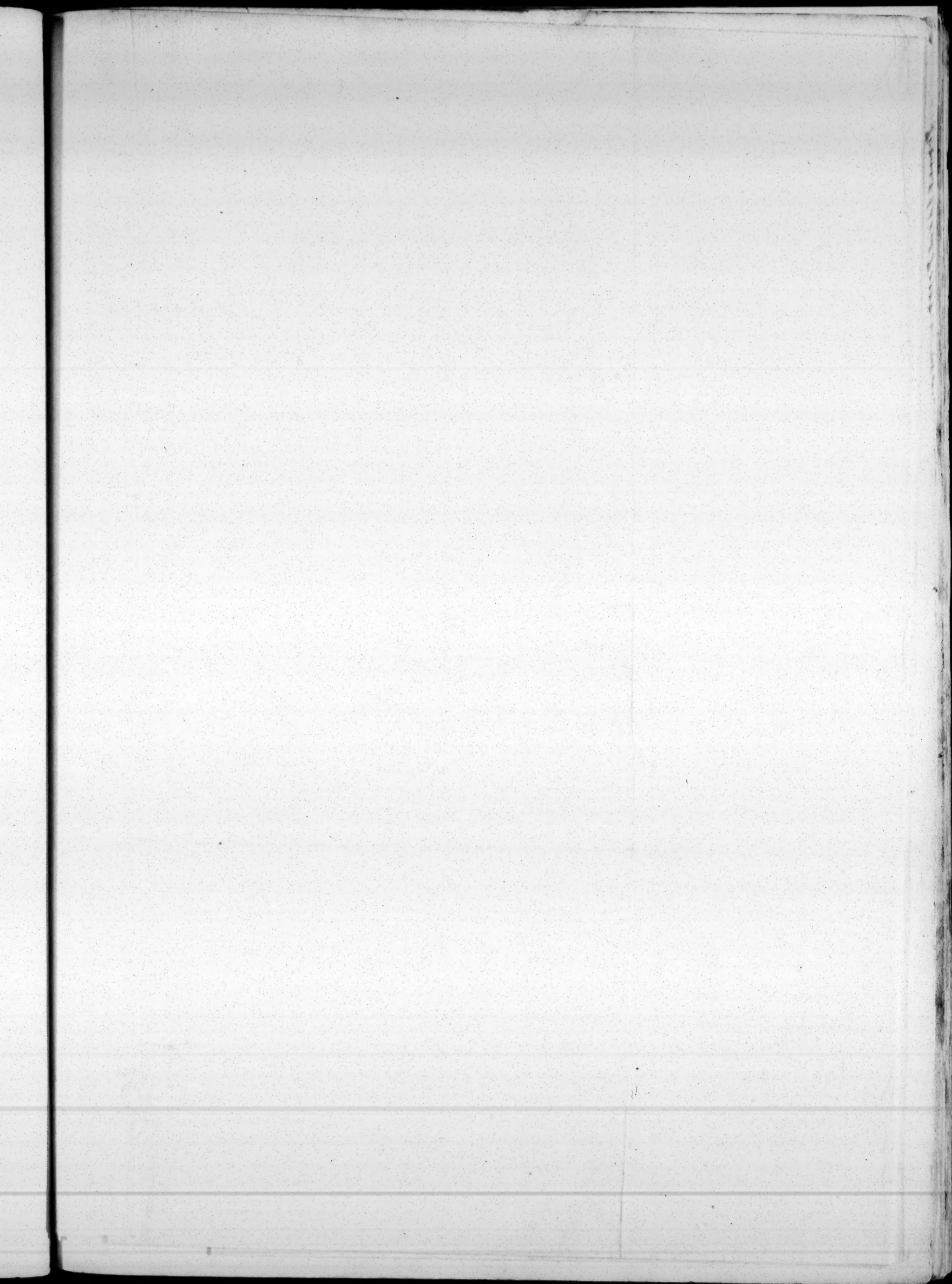which makes it fall down and flide backward
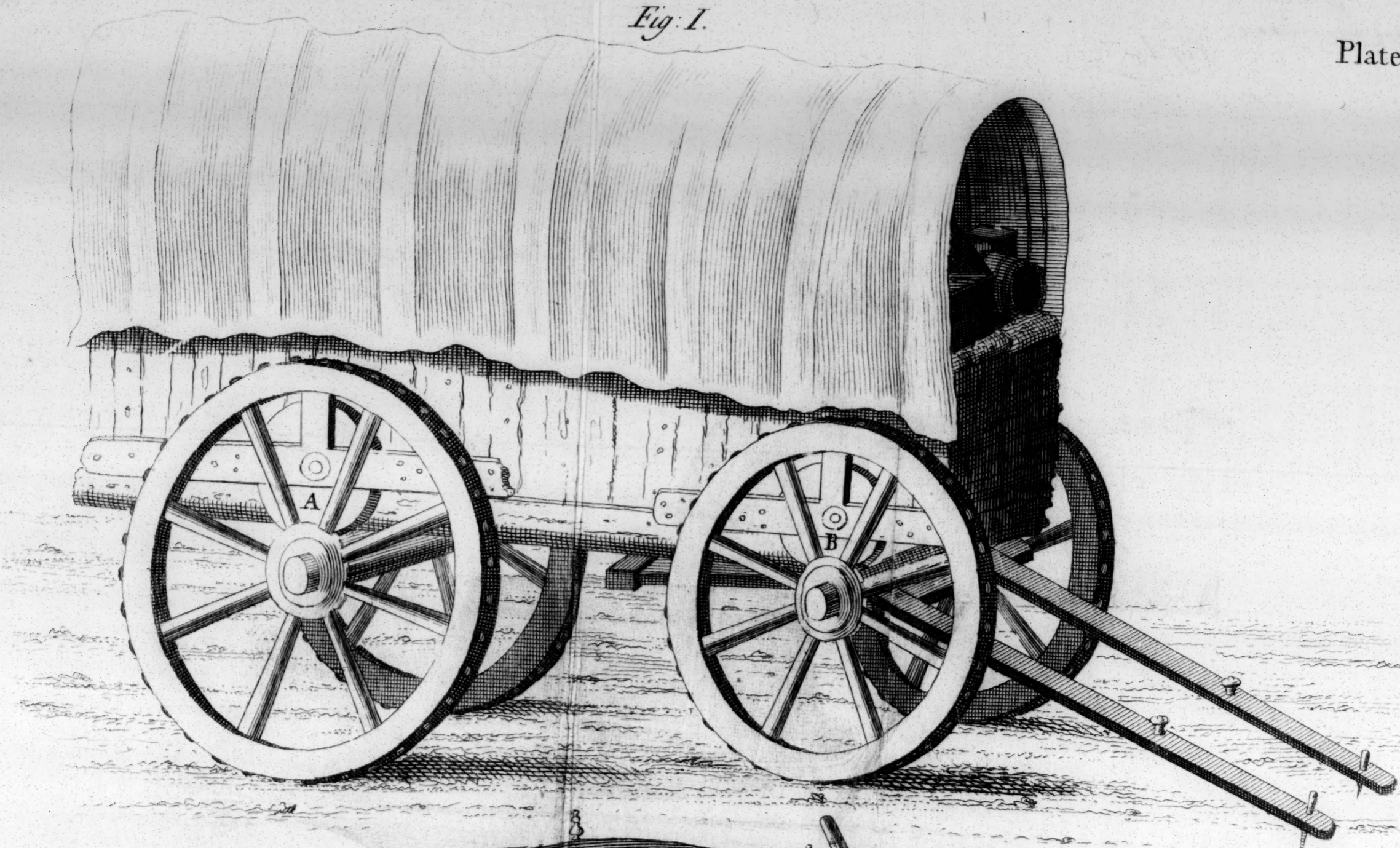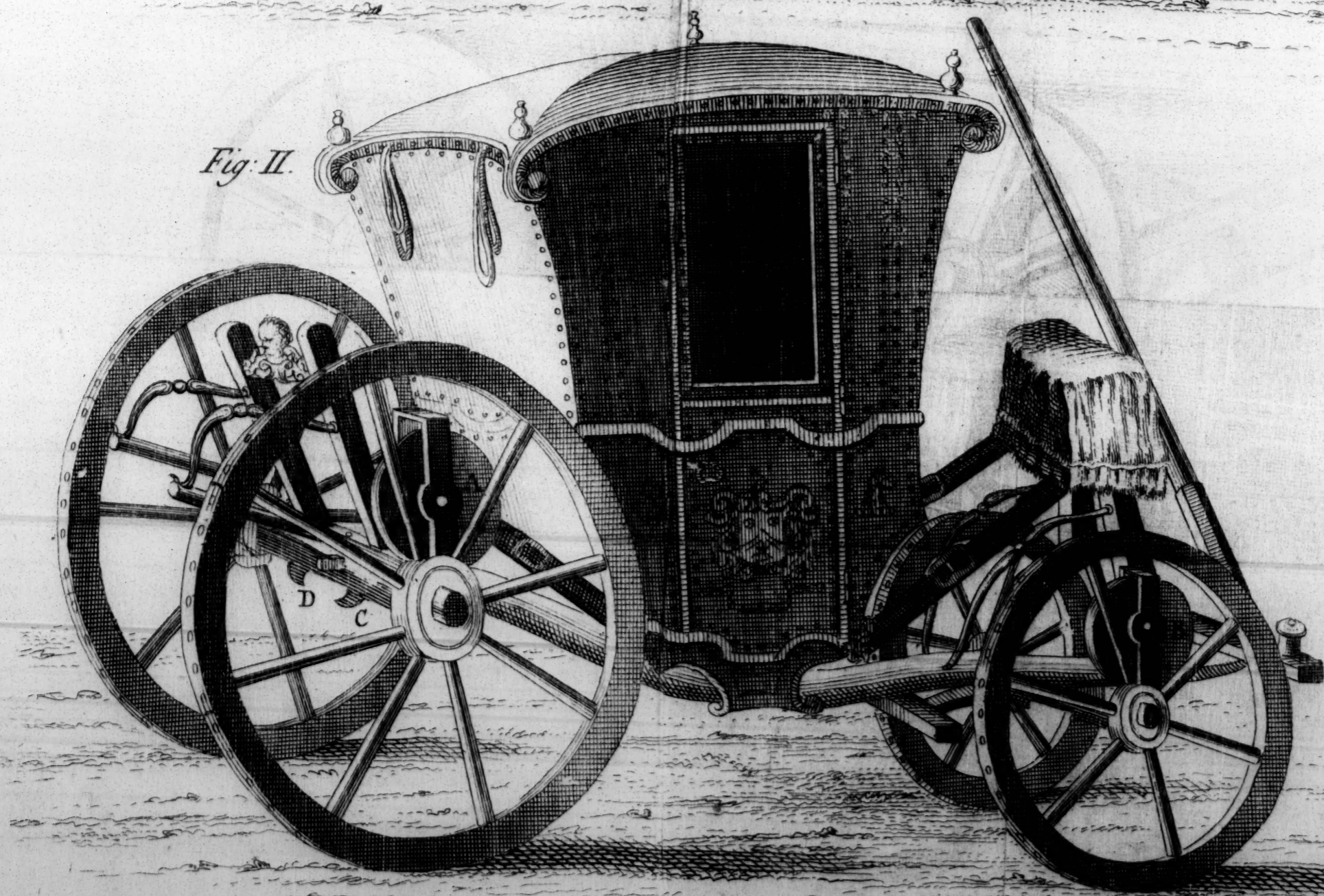
in

in the said Nave, whereby the said Axis then turns counter, or in oppofition to the Motion of the perpendicular Friction Wheels ; the which may be prevented by means of a Pin contrived to faften the Axis to the Nave, which may fo remain during the time that the Coach is to drive in a ftrait Road, and may be taken out in turning fhort, or out of a ftiff and deep Rut; but it will be lefs troublefome to caufe the Axis in the Nave continually to turn pretty ftiff, which may be performed by means of Springs fixed in the Iron Boxes.

An

An Estimate of the Advantages that will accrue to the Publick, by means of Cancelling the Friction of the Wheel, Pulley, Balance, Pendulum, &c.

AS I have no other design but to make this Calculation considerably within value, so will I only compute the saving in Wheel Carriage, (by means of diminishing the Friction) only in drawing up Hill (without the additional help by the Wind Tackle) which is about two for one; that is, one Horse will draw as much as two in the common way: And then suppose the labour of a Horse to be valued at one shilling and six pence *per* day, and that forty thousand are employed in this Kingdom in Wheel Carriage, there will consequently be a gain in the whole of 1,095,000 pounds *per annum*, or 3000 pounds *per* day. But as one Horse now will do the labour of two, I will suppose that there will be occasion to employ only twenty thousand, and consequently the expence of twenty thousand Horses, allowing the

the keeping of a Horſe one with another in town and country to be ten pounds *per annum*, then that Deficiency will be a ſaving of two hundred thouſand pounds; and what will be gained by the labour of the remaining twenty thouſand, preferable to what is common, will be 547500, which added to two hundred thouſand pounds, makes in the whole, according to this ſecond Calculation, 747,500 *per annum*, which is the loweſt Calculation. But though I make this Calculation to make the advantage appear leſs for the Publick than it really is, I am very far from thinking that there will be occaſion for fewer Horſes than at preſent, but rather more; for now great numbers of Mines will be worked more than at preſent, and ſuch as were not practicable before, by means of their remote diſtances from Water, and the poorneſs of the Ore; ſo as the Carriage to Mills and Water for cleaning the ſame eat up the profit, will now be carried on Wheel Carriages at a vaſtly cheaper rate than hitherto; and conſequently there will be a greater Demand for Horſes than at preſent; only I muſt own that there will not be occaſion to employ

employ fo large and heavy Horfes as common; for the Draught that is now required being confiderably lefs than ufual, we fhall want Horfes for Speed more than Draught.

And again, All forcible Engines where Wheels, &c. are concern'd, the moft fimple ones, by means of Friction, require a third more Power than will otherwife be needful; fo that if within this Kingdom we fuppofe all the charges in working the various forts of Engines employed in Mines, Coal-Pits, Mill-work, &c. to amount to fix hundred thoufand pounds *per annum*, then the Savings, by taking off the Friction, will be two hundred thoufand pound, which added to 747500, makes in the whole 947500 *per annum* : Befides being able to carry Dung, and all forts of Dreffings for Land fo much cheaper than ordinary, great quantities of barren Land will now be made fertile, which the great charges by the common way of Carriage hath hitherto rendered impracticable.

F I N I S.